

## CLAIMS:

1. A ceramic material, said ceramic material comprising at least one ceramic phase, wherein said at least one ceramic phase has an ordered structure on a nanoscale, and wherein said ordered structure is thermally stable up to a temperature of at least about 800°C.
2. The ceramic material according to Claim 1, wherein said at least one ceramic phase comprises one of an oxide, a carbide, a nitride, a boride, and combinations thereof.
3. The ceramic material according to Claim 2, wherein said at least one ceramic phase comprises at least one of silicon carbide, silicon nitride, silicon carbonitride, silicon oxynitride, silicon boron carbonitride, boron nitride, boron carbide, boron carbonitride, and combinations thereof.
4. The ceramic material according to Claim 1, wherein said ceramic material has a porosity of less than about 30 percent.
5. The ceramic material according to Claim 1, wherein said ordered structure comprises at least one of a lamellar structure, a perforated lamellar structure, a hexagonal structure, a cubic structure, a gyroid structure, a double gyroid structure, a double diamond structure, and a bi-continuous structure.
6. The ceramic material according to Claim 1, wherein said ordered structure has a periodicity that extends over a scale ranging from about 1 nm to about 1000 nm.
7. The ceramic material according to Claim 6, wherein said ordered structure has a periodicity that extends over a scale ranging from about 10 nm to about 100 nm.
8. The ceramic material according to Claim 1, further comprising a second ordered structure, said second ordered structure having a scale ranging from about one micron to about five millimeters.

9. The ceramic material according to Claim 1, wherein said ceramic material forms a portion of a hot gas path assembly component.

10. The ceramic material according to Claim 1, wherein said ordered structure is formed by: combining at least one polymeric precursor for said at least one ceramic phase and at least one block copolymer; ordering said at least one polymeric precursor and said at least one block copolymer; and pyrolyzing said at least one polymeric precursor and said at least one block copolymer to form said at least one ceramic phase.

11. The ceramic material according to Claim 1, wherein said ordered structure is thermally stable up to a temperature in a range from about 800°C to about 1800°C.

12. The ceramic material according to Claim 11, wherein said ordered structure is thermally stable up to a temperature in a range from about 1200°C to about 1500°C.

13. A ceramic material, said ceramic material comprising at least one ceramic phase, wherein said at least one ceramic phase has an ordered structure on a nanoscale, and wherein said ordered structure is thermally stable up to a temperature of at least about 800°C, and wherein said ceramic material is formed by:

a) forming a homogenized mixture of at least one polymeric precursor of said at least one ceramic phase and at least one block copolymer;

b) forming said ordered structure by curing said at least one polymeric precursor and self-assembly of said at least one block copolymer;

c) pyrolyzing said at least one polymeric precursor and said at least one block copolymer to decompose at least a portion of said block copolymer; and

d) converting said at least one polymeric precursor to form said at least one ceramic phase, said at least one ceramic phase having an ordered structure.

14. The ceramic material according to Claim 13, wherein said at least one ceramic phase comprises one of an oxide, a carbide, a nitride, a boride, and combinations thereof.

15. The ceramic material according to Claim 14, wherein said at least one ceramic phase comprises at least one of silicon carbide, silicon nitride, silicon carbonitride, silicon oxynitride, silicon boron carbonitride, boron nitride, boron carbide, boron carbonitride, and combinations thereof.

16. The ceramic material according to claim 13, wherein said at least one ceramic phase has a porosity of less than about 30 percent.

17. The ceramic material according to Claim 13, wherein said ordered structure comprises at least one of a lamellar structure, a hexagonal structure, a cubic structure, a perforated lamellar structure, a gyroid structure, a double diamond structure, and a bicontinuous structure.

18. The ceramic material according to Claim 13, wherein said ordered structure has a periodicity that extends over a scale ranging from about 1 nm to about 1000 nm.

19. The ceramic material according to Claim 18, wherein said ordered structure has a periodicity that extends over a scale ranging from about 10 nm to about 100 nm.

20. The ceramic material according to Claim 13, further comprising a second ordered structure, said second ordered structure having a scale ranging from about one micron to about five millimeters.

21. The ceramic material according to Claim 13, wherein said ordered structure is thermally stable up to a temperature in a range from about 800°C to about 1800°C.

22. The ceramic material according to Claim 21, wherein said ordered structure is thermally stable up to a temperature in a range from about 1200°C to about 1500°C.

23. A ceramic material, said ceramic material comprising at least one ceramic phase, wherein said at least one ceramic phase comprises one of an oxide, a carbide, a nitride, a boride, and combinations thereof, and has an ordered structure on a nanoscale, wherein said ordered structure is thermally stable up to a temperature of at least about 800°C, and wherein said at least one ceramic phase is formed by:

a) forming a homogenized mixture of at least one polymeric precursor of said at least one ceramic phase and at least one block copolymer;

b) forming said ordered structure by curing said at least one polymeric precursor and self-assembly of said at least one block copolymer;

c) pyrolyzing said at least one polymeric precursor and said at least one block copolymer to remove said at least one block copolymer; and

d) converting said at least one polymeric precursor to form said at least one ceramic phase, said at least one ceramic phase having an ordered structure.

24. The ceramic material according to Claim 23, wherein said at least one ceramic phase comprises at least one of silicon carbide, silicon nitride, silicon carbonitride, silicon oxynitride, silicon boron carbonitride, boron nitride, boron carbide, boron carbonitride, and combinations thereof.

25. The ceramic material according to Claim 23, wherein said ceramic material has a porosity of less than about 30 percent.

26. The ceramic material according to Claim 23, wherein said ordered structure comprises at least one of a lamellar structure, a hexagonal structure, and a cubic structure, a perforated lamellar structure, a gyroid structure, a double diamond structure, and a bicontinuous structure.

27. The ceramic material according to Claim 23, wherein said ordered structure has a periodicity that extends over a scale ranging from about 1 nm to about 1000 nm.

28. The ceramic material according to Claim 27, wherein said ordered structure has a periodicity that extends over a scale ranging from about 10 nm to about 100 nm.

29. The ceramic material according to Claim 23, further comprising a second ordered structure, said second ordered structure having a scale ranging from about one micron to about five millimeters.

30. The ceramic material according to Claim 23, wherein said ceramic material forms a portion of a high strength structural component.

31. The ceramic material according to Claim 23, wherein said ceramic material forms a portion of a hot gas path assembly component.

32. A method of making a ceramic material, the ceramic material comprising at least one ceramic phase having an ordered structure on a nanoscale, and wherein the ordered structure is thermally stable up to a temperature of at least about 800°C, the method comprising the steps of:

a) providing at least one polymeric precursor for the at least one ceramic phase and at least one block copolymer;

b) forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer;

c) forming an ordered structure by curing the at least one polymeric precursor and self-assembly of the at least one block copolymer;

d) pyrolyzing the at least one polymeric precursor and the at least one block copolymer to decompose at least a portion of the at least one block copolymer; and

e) converting the at least one polymeric precursor to form the at least one ceramic phase, the at least one ceramic phase having an ordered structure.

33. The method according to Claim 32, wherein the at least one polymeric precursor is at least one of polysilazane, polycarbosilane, polyboroncarbosilane, polyborocarbosilazane, polyborazylene and combinations thereof.

34. The method according to Claim 32, further including the step of providing at least one free radical initiator.

35. The method according to Claim 34, wherein the at least one free radical initiator comprises an organic peroxide, an alkoxyamine, a dithioester, and combinations thereof.

36. The method according to Claim 35, wherein the organic peroxide is a cumyl peroxide.

37. The method according to Claim 34, wherein the step of forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer comprises forming a homogenized mixture of the at least one polymeric precursor, the at least one free radical initiator, and the at least one block copolymer.

38. The method according to Claim 32, wherein the at least one block copolymer comprises at least one of a poly (butadiene), poly (ethylene oxide), polyisoprene, polydimethylsiloxane, polystyrene, polyvinylpyridene, polyethylene, polypropylene, polypropylene oxide, polyethylene propylene, polyacrylates, polymethacrylates, polylactides, polyacrylonitrile, and combinations thereof.

39. The method according to Claim 32, wherein the step of forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer comprises forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer, wherein the at least one block copolymer and the at least one polymeric precursor are present in the

homogenized mixture in a weight ratio in a range from about 95:5 to about 5:95 by weight.

40. The method according to Claim 32, wherein the step of providing at least one polymeric precursor for the at least one ceramic phase and at least one block copolymer comprises:

a) forming a first solution of the at least one polymeric precursor in an organic solvent; and

b) forming a second solution of the at least one block copolymer in the organic solvent.

41. The method according to Claim 40, wherein the organic solvent comprises at least one of tetrahydrofuran, chloroform, hexane, benzene, and toluene.

42. The method according to Claim 40, wherein the first solution comprises from about 0.1 weight percent to about 10 weight percent of the at least one polymeric precursor.

43. The method according to Claim 42, wherein the first solution comprises from about 0.5 weight percent to about 5 weight percent of the at least one polymeric precursor.

44. The method according to Claim 40, wherein the step of forming a first solution of the at least one polymeric precursor in the organic solvent comprises forming a first solution of the at least one polymeric precursor and at least one free radical initiator in the organic solvent.

45. The method according to Claim 44, wherein the first solution comprises up to about 10 weight percent of the at least one free-radical initiator.

46. The method according to Claim 45, wherein the first solution comprises from about 0.5 weight percent to about 5 weight percent of the at least one free-radical initiator.

47. The method according to Claim 40, wherein the second solution comprises from about 0.5 weight percent to about 5 weight percent of the at least one block copolymer.

48. The method according to Claim 40, wherein the step of forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer comprises:

a) combining the first solution and the second solution to form the homogenized mixture; and

b) drying the homogenized mixture to remove the organic solvent.

49. The method according to Claim 32, wherein the step of forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer comprises melt mixing the at least one polymeric precursor and the at least one block copolymer.

50. The method according to Claim 49, wherein the step of melt mixing the at least one polymeric precursor and the at least one block copolymer comprises melt mixing the at least one polymeric precursor and the at least one block copolymer at a temperature that is between the lowest glass transition temperature of the at least one block copolymer and the decomposition temperature of the at least one block copolymer.

51. The method according to Claim 50, wherein the step of melt mixing the at least one polymeric precursor and the at least one block copolymer comprises melt mixing the at least one polymeric precursor, at least one free radical initiator, and the at least one block copolymer.

52. The method according to Claim 32, wherein the step of pyrolyzing the at least one polymeric precursor and the at least one block copolymer comprises heating the at least one polymeric precursor and the at least one block copolymer to an annealing temperature in a range from about 800°C to about 1500°C for a predetermined time period.



53. The method according to Claim 32, wherein the step of converting the at least one polymeric precursor to form the at least one ceramic phase comprises reacting the at least one polymeric precursor with at least one reactive gas at a temperature in a range from about 800°C to about 1500°C.

54. The method according to Claim 53, wherein the at least one reactive gas comprises one of ammonia, nitrogen, and combinations thereof.

55. The method according to Claim 32, wherein the at least one ceramic phase comprises at least one of an oxide, a carbide, a nitride, a boride, and combinations thereof.

56. The method according to Claim 55, wherein at least one ceramic phase comprises at least one of silicon carbide, silicon nitride, silicon carbonitride, silicon oxynitride, silicon boron carbonitride, boron nitride, boron carbide, boron carbonitride, and combinations thereof.

57. The method according to Claim 32, wherein the ordered structure comprises at least one of a lamellar structure, a hexagonal structure, a cubic structure, a perforated lamellar structure, a gyroid structure, a double diamond structure, and a bi-continuous structure.

58. A method of making an article, the article comprising at least one ceramic phase having an ordered structure on a nanoscale, wherein the ordered structure is thermally stable up to a temperature of at least about 800°C, the method comprising the steps of:

- a) providing at least one polymeric precursor for the at least one ceramic phase and at least one block copolymer;
- b) forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer;
- c) casting the homogenized mixture into a preform of the article;

d) forming an ordered structure by curing the at least one polymeric precursor and self-assembly of the at least one block copolymer in the preform;

e) pyrolyzing the preform to decompose at least a portion of the at least one block copolymer; and

f) converting the at least one polymeric precursor in the preform to form the article comprising the at least one ceramic phase having an ordered structure.

59. The method according to Claim 58, further including the step of providing at least one free radical initiator.

60. The method according to Claim 58, wherein the step of forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer comprises forming a homogenized mixture of the at least one polymeric precursor, the at least one free radical initiator, and the at least one block copolymer.

61. The method according to Claim 58, further including the step of molding the preform into a shape.

62. The method according to Claim 58, wherein the step of casting the homogenized mixture into a preform of the article comprises infiltrating of the homogenized mixture into a porous matrix.

63. The method according to Claim 58, wherein the step of providing at least one polymeric precursor for the at least one ceramic phase and at least one block copolymer comprises:

a) forming a first solution of the at least one polymeric precursor in an organic solvent; and

b) forming a second solution of the at least one block copolymer in the organic solvent.

64. The method according to Claim 63, wherein the step of forming the first solution of the at least one polymeric precursor in the organic solvent comprises forming the first solution of the at least one polymeric precursor and at least one free radical initiator in the organic solvent.

65. The method according to Claim 63, wherein the step of forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer comprises:

a) combining the first solution and the second solution to form the homogenized mixture; and

b) drying the homogenized mixture to remove the organic solvent.

66. The method according to Claim 58, wherein the step of forming a homogenized mixture of the at least one polymeric precursor and the at least one block copolymer comprises melt mixing the at least one polymeric precursor and the at least one block copolymer.

67. The method according to Claim 66, wherein the step of melt mixing the at least one polymeric precursor and the at least one block copolymer comprises melt mixing the at least one polymeric precursor, at least one free radical initiator, and the at least one block copolymer.

68. The method according to Claim 58, wherein the step of pyrolyzing the at least one polymeric precursor and the at least one block copolymer in the preform comprises heating the preform to an annealing temperature in a range from about 800°C to about 1500°C for a predetermined time period.

69. The method according to Claim 58, wherein the step of converting the at least one polymeric precursor to form the at least one ceramic phase comprises reacting the at least one polymeric precursor with at least one reactive gas at a temperature in a range from about 800°C to about 1500°C.

70. The method according to Claim 69, wherein the at least one reactive gas comprises one of ammonia, nitrogen, and combinations thereof.

71. The method according to Claim 58, wherein the at least one ceramic phase comprises at least one of an oxide, a carbide, a nitride, a boride, and combinations thereof.

72. The method according to Claim 71, wherein at least one ceramic phase comprises at least one of silicon carbide, silicon nitride, silicon carbonitride, silicon oxynitride, silicon boron carbonitride, boron nitride, boron carbide, boron carbonitride, and combinations thereof.

73. The method according to Claim 58, wherein the ordered structure comprises at least one of a lamellar structure, a hexagonal structure, a cubic structure, a perforated lamellar structure, a gyroid structure, a double diamond structure, and a bi-continuous structure.

74. The method according to Claim 58, wherein the article is a hot gas path assembly component.